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N63 23037
CODE-1
(NASA CR 51597)

IMPROVEMENT OF NICKEL-CADMIUM

BATTERIES

MONTHLY TECHNICAL PROGRESS REPORT NO. 28, July 20 - Aug. 20, 1963

COVERING THE PERIOD

20 July 1963 to 20 August 1963

[1963] 24P

OTS PRICE ↙

XEROX	\$	<u>2.60 pl</u>
MICROFILM	\$	<u>0.92 mf</u>

[5]

(^{NASA}
Contract No. NAS 5-1048)

INLAND TESTING LABORATORIES

Cook Technological Center

Dayton, Ohio

Cook Electric Co., Morton Grove, Ill

2248755

PROGRESS REPORT NO. 28

I. INTRODUCTION

This Progress Report is submitted in accordance with Article 1 and Item 2 of Article II, of Contract NAS 5-1048.

II. CONTRACT OBJECTIVE

The objective of this contract is to improve nickel-cadmium batteries through testing and analysis of failures. Specifically, a number of batteries developed by manufacturers under NASA Contracts are being subjected to operational and environmental testing to determine failure rates and modes of failure. From these results specific suggestions for the proper application and possible improvement of this battery type may be made.

III. PROGRAM FOR THE REPORT PERIOD

Cycle-life tests were continued and data recorded on the following groups of cells:

<u>Number of Cells in Original Group</u>	<u>Mfr.</u>	<u>Depth of Discharge</u>	<u>Temp. °C</u>	<u>Cycles Completed</u>
10	Sonotone	10%	25	4100+
10	Gulton	10%	25	4100+
10	Gould	10%	25	4100+
10	Sonotone	10%	50	3900+
10	Gulton	10%	50	3900+
10	Gould	10%	50	3900+

<u>Number of Cells in Original Group</u>	<u>Mfr.</u>	<u>Depth of Discharge</u>	<u>Temp. °C</u>	<u>Cycles Completed</u>
10	Sonotone	25%	25	3800+
10	Gould	25%	25	1000+
10	Gulton	25%	25	3800+
10	Sonotone	10%	-10	3600+
5	Gould	10%	-10	2500+
10	Gulton	10%	-10	3600+
4	Sonotone	40%	25	2800+
5	Gould	40%	25	1000+

During this reporting period, all cell groups in the five operating conditions cycled in a normal pattern with the exception of the Gould National cells cycling at 50°C and 10% discharge; and at 25°C and 40% discharge.

Cell No. 42 was removed from cycling after 3576 cycles at 50°C and 10% discharge. (End-of-discharge voltages after 3489 cycles were below 1.0 Volt.)

Cell Nos. 46 and 50 were removed from cycling after 864 cycles at 25°C and 40% discharge. (End-of-discharge voltages were below 1.0 Volt after 576 and 475 cycles, respectively.)

After removal from the cycling test, a post failure test was performed on each cell. Cell No. 42 had negligible capacity when a discharge test was performed. It also would not hold its open circuit voltage after it was recharged.

Cells Nos. 46 and 50 took a charge readily, came up to a normal end of charge voltage and after a discharge at C/2 were found to have regained a little less than half of their original capacity after one charge C/10 for 16 hours. After another such charge they held an open circuit voltage of 1.33 volts for 120 hours, when observations were discontinued.

A separate report on the procedure and results of these three tests is appended.

A preliminary analysis reveals that ^{the} main oxide in the coating over the ceramic seal of the previously failed Gulton cells is silver. The seal of one cell, which was not completely coated, shows that oxidation first occurred at the "fused seam" between the ceramic and metal, where brazing material evidently was exposed. No further failures of this type have occurred over the last 1900 cycles.

VI. PROGRAM FOR THE NEXT PERIOD

1. Continue and record data on cycle-life tests in progress at 25°C, -10°C, and 50°C.
2. Continue evaluation of data being accumulated.
3. Continue investigation of failed cells.

FINANCIAL CONDITION

CONTRACT NAS 5-1048

MONTHLY PROGRESS REPORT NO. 28

20 JULY 1963 to 20 AUGUST 1963

* Funds Expended During Report Period \$ 903

* Commitments None

* Total Funds Expended Including Commitments \$54, 050

* Funds Remaining \$ 2, 717

* All amounts are less G & A and Fee

POST FAILURE TESTS ON GOULD NATIONAL CELLS

CELL NO. 42 - EVIDENCE OF MINOR LEAKAGE - (50°C - 10%)

Removed after 3576 cycles (cell voltage below 1.0V. after 3489 cycles)

Open Circuit Voltage as removed from cycling - - - - - 1.16V.

Charged at C/10 for 16 hours - End of Charge Voltage - - - 1.36V.

After 1 hour stand, Open Circuit Voltage at start of C/2

discharge - - - - - 1.18V.

<u>Discharge Time (Min)</u>	<u>Terminal Voltage</u>	<u>Capacity - A. H.</u>
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0.3	0.80 V.	
0.5	0.70 V.	
1.0	0.60 V.	0.028

At end of C/10 charge for 16 hours, Open Circuit Voltage - - 1.36V.

At end of 24 hours, O.C. V. - - - - - 1.10V.

At end of 48 hours, O.C. V. - - - - - 0.82V.

At end of 120 hours, O.C. V. - - - - - 0.08V.

CELL NO. 46 - EVIDENCE OF MINOR LEAKAGE - (25°C - 40%)

Cell voltage went below 1.0V. after 576 cycles and cell removed from cycling after 864 cycles.

Open Circuit Voltage as removed from cycling - - - - - 1.02V.

Charged at C/10 for 16 hours - End of Charge Voltage - - - 1.48V.

After 1 hour stand, Open Circuit Voltage at start of C/2

discharge - - - - - 1.36V.

<u>Discharge Time (Min)</u>	<u>Terminal Voltage</u>	<u>Capacity - A. H.</u>
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1	1.21 V.	
10	1.10 V.	
30	1.07 V.	
54	1.00 V.	1.57
93	0.60 V.	2.42

At end of C/10 charge for 16 hours - Open Circuit Voltage - - - 1.39V.

At end of 24 hours, O.C. V. - - - - - 1.34V.

At end of 120 hours, O.C. V. - - - - - 1.33V.

After 120 hrs. O.C., capacity to 1.0 volt at C/2 rate - - - - 1.14A.H.

POST FAILURE TESTS ON GOULD NATIONAL CELLS

CELL NO. 50 - EVIDENCE OF MINOR LEAKAGE - (25°C ~ 40%)

Cell voltage went below 1.0 volt after 475 cycles and cell removed from cycling after 864 cycles.

Open Circuit Voltage as removed from cycling - - - - - 0.98V.

Charged at C/10 for 16 hours - End of Charge Voltage - - - 1.47V.

After 1 hour stand, Open Circuit Voltage at start of C/2 discharge - - - - - 1.36V.

<u>Discharge Time (Min)</u>	<u>Terminal Voltage</u>	<u>Capacity - A. H.</u>
1	1.20 V.	
30	1.08 V.	
63	1.00 V.	1.84
86	0.60 V.	2.51

At end of C/10 charge for 16 hours - Open Circuit Voltage - - - 1.40V.

At end of 24 hours - O.C.V. - - - - - 1.35V.

At end of 120 hours - O.C.V. - - - - - 1.33V.

After 120 hrs. O.C., capacity to 1.0 Volt at C/2 rate - - - - 1.56A.H.

DISPOSITION OF SONOTONE CELLS - 20 AUGUST 1963

Cells - Failed Initial Tests - - - - -	6
Cells - Failed in Cycling to Date - - - - -	2
Cells - Now Cycling - - - - -	42

CELLS FAILED INITIAL TESTS

Electrolyte Leakage - - - - -	4
Electrical Leakage - - - - -	2

CELLS FAILED IN CYCLING TO DATE

25°C - 40% Discharge (537 cycles) - - - - -	1
50°C - 10% Discharge (3288 cycles) - - - - -	1
Total	2

CELLS NOW CYCLING

At 25°C - 10% Discharge - - - - -	10
At 25°C - 25% Discharge - - - - -	10
At 25°C - 40% Discharge - - - - -	3
At 50°C - 10% Discharge - - - - -	9
At -10°C - 10% Discharge - - - - -	10
Total	42

DISPOSITION OF GOULD NATIONAL CELLS - 20 AUGUST 1963

Cells - Failed Initial Tests - - - - -	23
Cells - Failed in Cycling - - - - -	7
Cells - Now Cycling - - - - -	33
Cells - Not Used in Cycling - - - - -	2*

* One cell bulged, one leaked after initial tests

CELLS FAILED INITIAL TESTS

Electrolyte Leakage - - - - -	23
Electrical Leakage - - - - -	2 (Failed Both Initial Tests)

CELLS FAILED IN CYCLING

At 50°C - 10% Discharge (2668) cycles - - - - -	1
At 50°C - 10% Discharge (2973) cycles - - - - -	1
At 50°C - 10% Discharge (3216) cycles - - - - -	1
At 50°C - 10% Discharge (3372) cycles - - - - -	1
At 50°C - 10% Discharge (3576) cycles - - - - -	1
At 25°C - 40% Discharge (864) cycles - - - - -	2
Total	7

CELLS NOW CYCLING

At 25°C - 10% Discharge - - - - -	10
At 50°C - 10% Discharge - - - - -	5
At -10°C - 10% Discharge - - - - -	5
At 25°C - 25% Discharge - - - - -	10
At 25°C - 40% Discharge - - - - -	3

NOTE: These last two groups totaling 15 cells are from the group of 23 cells reported as having electrolyte leakage. They were sent to the manufacturer for examination, returned to this facility, and are now cycling as indicated.

DISPOSITION OF GULTON CELLS - 20 AUGUST 1963

Cells - Failed Initial Tests	- - - - -	7
Cells - Failed in Cycling	- - - - -	4
Cells - Now Cycling	- - - - -	36
Cells - Not Used in Cycling	- - - - -	3*

* 3 cells bulged after initial tests

CELLS FAILED INITIAL TESTS

Electrolyte Leakage	- - - - -	5
Electrical Leakage	- - - - -	2

CELLS FAILED IN CYCLING TO DATE

At 25°C - 10% Discharge (2263 cycles)	- - - - -	1
At 25°C - 25% Discharge (1298 cycles)	- - - - -	1
At 25°C - 25% Discharge (1270 cycles)	- - - - -	1
At 25°C - 25% Discharge (1416 cycles)	- - - - -	1
	Total	4

CELLS NOW CYCLING

At 25°C - 10% Discharge	- - - - -	9
At 25°C - 25% Discharge	- - - - -	7
At 50°C - 10% Discharge	- - - - -	10
At -10°C - 10% Discharge	- - - - -	10
	Total	36

GENERAL DATA SHEET

TEST Cycle Life at 25°C	SPEC:	PAR:	TEST NO: Report 28		
CONDITIONING: Chg: 125% of Dischg. 60 min; Dischg: 10% Depth. 40 min.	DATE: 20 Aug. 1963				
MATERIAL: Ni-Cad; 10 Cell Group. Rated 3.5 A.H.	TEMP: RH:				
MANUFACTURER: Sonotone	M. NO:				
INSTRUMENTS: Milliammeter, D.C. Sensitive Research, Model UUP, 1/2%. Voltmeter, D.C. Weston 931, 5000 ohms/volt, 1/2%	TESTED BY: D. M. LAB SUP CHECK: H. B. ENGRG CHECK: I. F. L.				
Cell No.	3776	CYCLE NUMBER	4006	4106	
		3833 END OF CHARGE VOLTAGE			
64	1.42	1.41	1.42	1.41	1.42
65	1.50	1.49	1.50	1.50	1.51
66	1.59	1.58	1.58	1.57	1.59
68	1.46	1.45	1.46	1.46	1.46
74	1.42	1.41	1.41	1.42	1.42
R39	1.44	1.43	1.43	1.44	1.43
R40	1.44	1.43	1.43	1.44	1.44
R41	1.43	1.43	1.43	1.44	1.44
R42	1.57	1.57	1.58	1.59	1.59
R43	1.48	1.44	1.44	1.44	1.45
END OF DISCHARGE VOLTAGE					
64	1.22	1.21	1.21	1.22	1.22
65	1.23	1.22	1.23	1.23	1.22
66	1.22	1.21	1.22	1.22	1.22
68	1.22	1.22	1.23	1.23	1.23
74	1.21	1.20	1.21	1.21	1.21
R39	1.20	1.20	1.20	1.20	1.20
R40	1.22	1.21	1.22	1.22	1.22
R41	1.23	1.22	1.23	1.23	1.23
R42	1.23	1.23	1.23	1.24	1.23
R43	1.22	1.22	1.22	1.23	1.22

GENERAL DATA SHEET

TEST Cycle Life at 25°C	SPEC:	PAR:	TEST NO: Report 28			
CONDITIONING: Chg: 125% of Dischg, 60 min; Dischg: 10% Depth, 40 min.			DATE: 20 Aug. 1963			
MATERIAL: Ni-Cad; 10 Cell Group, Rated 3.5 A. H.			TEMP: RH:			
MANUFACTURER: Gould National			M. NO:			
INSTRUMENTS: Milliammeter, D.C. Sensitive Research, Model UUP, 1/2% Voltmeter, D.C. Weston 931, 5000 ohms/volt, 1/2%			TESTED BY: D. M. LAB SUP CHECK: H. B. ENGRG CHECK: I. F. L.			
Cell No.	CYCLE NUMBER					
	3776	3833	3920	4006	4106	
	END OF CHARGE VOLTAGE					
1	1.45	1.44	1.45	1.46	1.45	
6	1.46	1.45	1.45	1.46	1.46	
8	1.45	1.44	1.44	1.45	1.45	
9	1.46	1.45	1.45	1.45	1.46	
10	1.48	1.48	1.48	1.48	1.48	
12	1.42	1.42	1.42	1.42	1.43	
14	1.44	1.45	1.46	1.46	1.46	
15	1.44	1.44	1.44	1.44	1.45	
22	1.46	1.45	1.45	1.45	1.46	
24	1.44	1.45	1.44	1.45	1.44	
	END OF DISCHARGE VOLTAGE					
1	1.26	1.26	1.26	1.26	1.26	
6	1.27	1.27	1.27	1.27	1.28	
8	1.26	1.26	1.26	1.27	1.26	
9	1.27	1.27	1.27	1.28	1.28	
10	1.25	1.25	1.26	1.26	1.25	
12	1.26	1.26	1.26	1.26	1.26	
14	1.27	1.27	1.27	1.28	1.27	
15	1.26	1.26	1.27	1.26	1.26	
22	1.27	1.26	1.27	1.27	1.27	
24	1.26	1.26	1.28	1.27	1.27	
2						

GENERAL DATA SHEET

TEST Cycle Life at 25°C	SPEC:	PAR:	TEST NO: Report 28		
CONDITIONING: Chg: 125% of dischg, 60 min; Dischg: 10% Depth, 40 min.			DATE: 20 Aug. 1963		
MATERIAL: Ni-Cad; 9 Cell Group, Rated 6 A.H.			TEMP: RH:		
MANUFACTURER: Gulton			M. NO: VO-6HS		
INSTRUMENTS: Milliammeter, D.C. Sensitive Research, Model UUP, 1/2% Voltmeter, D.C. Weston 931, 5000 ohms/volt, 1/2%			TESTED BY: D. M. LAB SUP CHECK: H. B. ENGRG CHECK: I. F. L.		
Cell No.	CYCLE NUMBER				
	3776	3833	3920	4006	4106
	END OF CHARGE VOLTAGE				
628	1.42	1.41	1.42	1.41	1.42
638	1.41	1.41	1.41	1.41	1.40
644	1.43	1.42	1.42	1.42	1.42
647	1.42	1.41	1.42	1.42	1.42
648	1.40	1.40	1.40	1.40	1.40
653	1.42	1.41	1.42	1.41	1.42
822	1.42	1.41	1.41	1.42	1.42
825	1.41	1.41	1.41	1.41	1.41
827	1.42	1.42	1.41	1.41	1.42
	END OF DISCHARGE VOLTAGE				
628	1.20	1.21	1.21	1.22	1.22
638	1.24	1.24	1.25	1.25	1.24
644	1.25	1.25	1.25	1.25	1.25
647	1.25	1.25	1.26	1.25	1.25
648	1.21	1.21	1.21	1.22	1.22
653	1.24	1.24	1.24	1.24	1.24
822	1.24	1.24	1.25	1.24	1.25
825	1.25	1.24	1.25	1.25	1.25
827	1.25	1.26	1.25	1.26	1.25
3					

GENERAL DATA SHEET

TEST	SPEC:	PAR:	TEST NO:
Cycle Life at 25°C			Report 28
CONDITIONING:			DATE:
Chg: 125% of dischg, 60 min; Dischg: 25% Depth, 40 min.			20 Aug. 1963
MATERIAL:			TEMP: RH:
Ni-Cad, 10 Cell Group, Rated 3.5 A. H.			M. NO:
MANUFACTURER:			
Sonotone			
INSTRUMENTS:			TESTED BY:
Milliammeter, D.C. Sensitive Research, Model UUP, 1/2%			D. M.
Voltmeter, D.C. Weston 931, 5000 ohms/volt, 1/2%			LAB SUP CHECK:
			H. B.
			ENGRG CHECK:
			I. F. L.
Cell No.	3476	CYCLE NUMBER	
		3533	3620
		END OF CHARGE VOLTAGE	3706
60	1.48	1.47	1.48
61	1.48	1.47	1.47
R49	1.46	1.46	1.46
R50	1.48	1.48	1.48
R51	1.49	1.48	1.48
R52	1.47	1.46	1.47
R53	1.46	1.45	1.46
R55	1.47	1.46	1.46
R56	1.47	1.46	1.47
R57	1.47	1.45	1.47
		END OF DISCHARGE VOLTAGE	
60	1.15	1.14	1.15
61	1.15	1.15	1.15
R49	1.12	1.10	1.12
R50	1.16	1.15	1.16
R51	1.17	1.17	1.18
R52	1.16	1.16	1.16
R53	1.15	1.15	1.15
R55	1.15	1.15	1.16
R56	1.16	1.16	1.17
R57	1.15	1.15	1.16

GENERAL DATA SHEET

TEST Cycle Life at 25°C	SPEC:	PAR:	TEST NO: Report 28
CONDITIONING: Chg: 125% of dischg, 60 min; Dischg: 25% Depth, 40 min.			DATE: 20 Aug. 1963
MATERIAL: Ni-Cad, 10 Cell Group, Rated 3.5 A. H.			TEMP: RH:
MANUFACTURER: Gould National			M. NO:
INSTRUMENTS: Milliammeter, D.C. Sensitive Research, Model UUP, 1/2% Voltmeter, D.C. Weston 931, 5000 ohms/volt, 1/2%			TESTED BY: D. M. LAB SUP CHECK: H. B. ENGRG CHECK: L. F. L.

Cell No.	CYCLE NUMBER				
	663	720	807	893	993
END OF CHARGE VOLTAGE					
3	1.49	1.48	1.49	1.49	1.48
5	1.48	1.48	1.49	1.49	1.49
7	1.56	1.57	1.54	1.54	1.54
11	1.48	1.48	1.48	1.48	1.48
13	1.53	1.51	1.52	1.52	1.52
16	1.50	1.49	1.49	1.49	1.49
30	1.49	1.49	1.49	1.49	1.49
37	1.54	1.52	1.54	1.55	1.53
39	1.52	1.50	1.52	1.51	1.51
40	1.50	1.48	1.50	1.49	1.48
END OF DISCHARGE VOLTAGE					
3	1.24	1.23	1.24	1.24	1.24
5	1.23	1.22	1.22	1.23	1.22
7	1.17	1.10	1.19	1.18	1.17
11	1.25	1.24	1.25	1.25	1.25
13	1.20	1.20	1.21	1.20	1.18
16	1.24	1.23	1.24	1.24	1.24
30	1.22	1.23	1.24	1.24	1.24
37	1.14	1.11	1.10	1.06	1.05
39	1.23	1.23	1.23	1.24	1.22
40	1.24	1.23	1.24	1.25	1.23
5					

GENERAL DATA SHEET

TEST Cycle Life at 25°C	SPEC:	PAR:	TEST NO: Report 28
CONDITIONING: Chg: 125% of dischg, 60 min; Dischg: 25% Depth, 40 min.			DATE: 20 Aug. 1963
MATERIAL: Ni-Cad; 7 Cell Group, Rated 6 A. H.			TEMP: RH:
MANUFACTURER: Gulton			M. NO: VO-6HS
INSTRUMENTS: Milliammeter, D.C. Sensitive Research, Model UUP, 1/2% Voltmeter, D.C. Weston 931, 5000 ohms/volt, 1/2%			TESTED BY: D. M. LAB SUP CHECK: H. B. ENGRG CHECK: I. F. L.

Cell No.	3476	3533	CYCLE NUMBER		3806
			END OF CHARGE	VOLTAGE	
660	1.46	1.45	1.45	1.46	1.46
661	1.48	1.46	1.47	1.47	1.47
804	1.51	1.50	1.50	1.51	1.50
812	1.46	1.46	1.47	1.47	1.46
816	1.46	1.45	1.45	1.45	1.45
818	1.45	1.44	1.45	1.45	1.44
820	1.46	1.45	1.46	1.46	1.46
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END OF DISCHARGE VOLTAGE					
660	1.10	1.10	1.14	1.17	1.15
661	1.12	1.11	1.15	1.18	1.15
804	1.16	1.15	1.15	1.17	1.15
812	1.12	1.12	1.14	1.18	1.16
816	1.10	1.11	1.14	1.16	1.15
818	1.11	1.11	1.13	1.18	1.14
820	1.11	1.12	1.14	1.17	1.15
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GENERAL DATA SHEET

TEST Cycle Life at 25°C	SPEC:	PAR:	TEST NO: Report 28		
CONDITIONING: Chg: 125% of Dischg, 60 min; Dischg: 40% Depth, 40 min.			DATE: 20 Aug. 1963		
MATERIAL: Ni-Cad; 3 Cell Group, Rated 3.5 A.H.			TEMP: RH:		
MANUFACTURER: Sonotone			M. NO:		
INSTRUMENTS: Milliammeter, D.C. Sensitive Research, Model UUP, 1/2% Voltmeter, D.C. Weston 931, 5000 ohms/volt, 1/2%			TESTED BY: D. M. LAB SUP CHECK: H. B. ENGRG CHECK: I. F. L.		
Cell No.	2476	CYCLE NUMBER			2806
		2533	END OF CHARGE VOLTAGE	2620	
57	1.52	1.50	1.51	1.51	1.51
58	1.51	1.51	1.50	1.51	1.51
59	1.51	1.51	1.51	1.51	1.51
END OF DISCHARGE VOLTAGE					
57	1.13	1.14	1.14	1.15	1.14
58	1.15	1.15	1.15	1.16	1.16
59	1.15	1.15	1.15	1.15	1.16

GENERAL DATA SHEET

TEST	SPEC:	PAR:	TEST NO:		
CYCLE LIFE AT 25°C			Report 28		
CONDITIONING:			DATE:		
Chg: 125% of dischg, 60 min; Dischg: 40% Depth, 40 min.			20 Aug. 1963		
MATERIAL:			TEMP: RH:		
Ni-Cad. 5 Cell Group, Rated 3.5 A.H.					
MANUFACTURER:			M. NO:		
Gould National					
INSTRUMENTS:			TESTED BY:		
Milliammeter, D.C. Sensitive Research, Model UUP, 1/2%			D. M.		
Voltmeter, D.C. Weston 931, 5000 ohms/volt, 1/2%			LAB SUP CHECK:		
			H. B.		
			ENGRG CHECK:		
			I. F. L.		
Cell No.	663	720 END OF CHARGE VOLTAGE	807	893	993
43	1.54	1.54	1.55	1.57	1.56
45	1.51	1.51	1.51	1.51	1.52
46	1.56	1.54	1.57	*	
49	1.56	1.56	1.54	1.54	1.56
50	1.58	1.57	1.56	*	
		END OF DISCHARGE VOLTAGE			
43	1.05	1.06	1.00	1.00	0.97
45	1.19	1.19	1.18	1.17	1.13
46	0.89	0.90	0.87	*	
49	1.13	1.12	1.10	1.06	1.02
50	0.94	0.97	0.92	*	
* Cell Nos. 46 and 50 removed at 864 cycles when discharge voltage went negative just at the end of discharge.					

GENERAL DATA SHEET

TEST Cycle Life at 50°C	SPEC:	PAR:	TEST NO: Report 28
CONDITIONING: Chg: 150% dischg, 60 min; Dischg: 10% Depth, 40 min.			DATE: 20 Aug. 1963
MATERIAL: Ni-Cad: 9 Cell Group, Rated 3.5 A.H.			TEMP: RH:
MANUFACTURER: Sonotone			M. NO:
INSTRUMENTS: Milliammeter, D.C. Sensitive Research, Model UUP, 1/2% Voltmeter, D.C. Weston 931, 5000 ohms/volt, 1/2%			TESTED BY: D. M. LAB SUP CHECK: H. B. ENRG CHECK: I. F. L.

Cell No.	3576	3633	CYCLE NUMBER			
			END OF CHARGE VOLTAGE	3720	3806	3906
67	1.42	1.41	1.41	1.41	1.41	1.41
69	1.40	1.40	1.40	1.40	1.40	1.40
70	1.42	1.42	1.42	1.42	1.42	1.42
71	1.38	1.37	1.38	1.39	1.38	1.38
75	1.39	1.39	1.40	1.40	1.39	1.39
R45	1.38	1.38	1.38	1.38	1.38	1.38
R46	1.38	1.38	1.38	1.37	1.37	1.37
R47	1.37	1.36	1.36	1.38	1.36	1.36
R48	1.38	1.38	1.39	1.38	1.38	1.38
END OF DISCHARGE VOLTAGE						
67	1.17	1.17	1.17	1.18	1.17	1.17
69	1.03	1.04	1.06	1.09	1.04	1.04
70	1.17	1.17	1.18	1.17	1.18	1.18
71	1.08	1.08	1.07	1.13	1.06	1.06
75	1.00	1.04	1.04	1.10	1.02	1.02
R45	1.20	1.20	1.20	1.20	1.21	1.21
R46	1.20	1.20	1.20	1.20	1.20	1.20
R47	1.18	1.18	1.19	1.21	1.19	1.19
R48	1.19	1.20	1.21	1.20	1.20	1.20

GENERAL DATA SHEET

TEST Cycle Life at 50°C	SPEC:	PAR:	TEST NO: Report 28			
CONDITIONING: Chg: 150% dischg, 60 min; Dischg: 10% Depth, 40 min.	DATE: 20 Aug. 1963					
MATERIAL: Ni-Cad; 6 Cell Group, Rated 3.5 A. H.	TEMP: RH:					
MANUFACTURER: Gould National	M. NO:					
INSTRUMENTS: Milliammeter, D.C. Sensitive Research, Model UUP, 1/2% Voltmeter, D.C. Weston 931, 5000 ohms/volt, 1/2%	TESTED BY: D. M. LAB SUP CHECK: H. B. ENRG CHECK: I. F. L.					
Cell No.	3576	3633	CYCLE NUMBER	END OF CHARGE VOLTAGE	3806	3906
23	1.40	1.39		1.40	1.41	1.41
28	1.41	1.41		1.40	1.41	1.41
31	1.43	1.42		1.41	1.40	1.40
32	1.46	1.46		1.45	1.46	1.46
33	1.45	1.44		1.43	1.43	1.43
42	1.40	*				
Cell No.	3576	3633	END OF DISCHARGE VOLTAGE	3806	3906	
23	1.19	1.18		1.19	1.21	1.20
28	1.18	1.19		1.18	1.20	1.20
31	1.22	1.21		1.21	1.22	1.21
32	1.24	1.23		1.23	1.23	1.22
33	1.14	1.15		1.14	1.13	1.14
42	*					
* Cell No. 42 removed at 3576 cycles when discharge voltage went negative.						
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GENERAL DATA SHEET

TEST	SPEC:	PAR:	TEST NO:		
Cycle Life at 50°C					
CONDITIONING:			DATE: 20 Aug. 1963		
Chg: 150% dischg, 60 min; Dischg: 10% Depth, 40 min.			TEMP: RH:		
MATERIAL:					
Ni-Cad; 10 Cell Group, Rated 6 A. H.					
MANUFACTURER:			M. NO:		
Gulton			VO-6HS		
INSTRUMENTS:			TESTED BY: D. M.		
Milliammeter, D. C. Sensitive Research, Model UUP, 1/2%			LAB SUP CHECK: H. B.		
Voltmeter, D. C. Weston 931, 5000 ohms/volt, 1/2%			ENGRG CHECK: I. F. L.		
Cell No.	3576	3633	CYCLE NUMBER	END OF CHARGE VOLTAGE	3906
602	1.42	1.41		1.42	1.42
604	1.40	1.40		1.40	1.40
610	1.36	1.37		1.35	1.38
611	1.39	1.37		1.39	1.39
616	1.41	1.40		1.41	1.41
624	1.39	1.39		1.39	1.39
719	1.39	1.39		1.39	1.39
765	1.40	1.40		1.40	1.40
778	1.40	1.40		1.40	1.40
779	1.40	1.40		1.41	1.40
Cell No.	3576	3633	CYCLE NUMBER	END OF DISCHARGE VOLTAGE	3906
602	1.24	1.23		1.24	1.23
604	1.19	1.20		1.21	1.20
610	1.13	1.12		1.10	1.19
611	1.20	1.18		1.23	1.21
616	1.22	1.22		1.23	1.22
624	1.19	1.19		1.20	1.18
719	1.18	1.19		1.18	1.18
765	1.19	1.20		1.20	1.20
778	1.18	1.18		1.20	1.19
779	1.17	1.18		1.20	1.19
II					

GENERAL DATA SHEET

TEST Cycle Life at -10°C	SPEC:	PAR:	TEST NO: Report 28
CONDITIONING: Chg: 115% of dischg. 60 min; Dischg: 10% Depth, 40 min.			DATE: 20 Aug. 1963
MATERIAL: Ni-Cad; 10 Cell Group, Rated 3.5 A. H.			TEMP: RH:
MANUFACTURER: Sonotone			M. NO:
INSTRUMENTS: Milliammeter, D.C. Sensitive Research, Model UUP, 1/2% Voltmeter, D.C. Weston 931, 5000 ohms/volt, 1/2%			TESTED BY: D. M. LAB SUP CHECK: H. B. ENGRG CHECK: I. F. L.

Cell No.	3276	CYCLE NUMBER			3606
		3333	END OF CHARGE VOLTAGE	3420	
51	1.52	1.52	1.53	1.52	1.52
52	1.49	1.50	1.50	1.49	1.50
53	1.55	1.55	1.54	1.54	1.56
54	1.65	1.63	1.63	1.64	1.65
55	1.61	1.61	1.60	1.63	1.62
73	1.50	1.50	1.51	1.50	1.50
R34	1.51	1.54	1.52	1.51	1.51
R35	1.59	1.60	1.60	1.59	1.59
R36	1.50	1.50	1.51	1.51	1.50
R38	1.62	1.61	1.60	1.59	1.62
END OF DISCHARGE VOLTAGE					
51	1.24	1.24	1.25	1.25	1.24
52	1.23	1.23	1.24	1.24	1.23
53	1.24	1.24	1.26	1.26	1.24
54	1.24	1.24	1.26	1.26	1.25
55	1.24	1.24	1.26	1.26	1.25
73	1.23	1.25	1.25	1.25	1.24
R34	1.24	1.25	1.26	1.26	1.25
R35	1.25	1.25	1.26	1.27	1.25
R36	1.24	1.24	1.25	1.26	1.24
R38	1.25	1.25	1.26	1.27	1.24
12					

GENERAL DATA SHEET

TEST	SPEC:	PAR:	TEST NO:		
Cycle Life at -10°C			Report 28		
CONDITIONING:			DATE:		
Chg: 115% of dischg. 60 min; Dischg: 10% Depth, 40 min.			20 Aug. 1963		
MATERIAL:			TEMP: RH:		
Ni-Cad; 5 Cell Group, Rated 3.5 A. H.					
MANUFACTURER:			M. NO:		
Gould National					
INSTRUMENTS:			TESTED BY:		
Milliammeter, D.C. Sensitive Research, Model UUP, 1/2%			D. M.		
Voltmeter, D.C. Weston 931, 5000 ohms/volt, 1/2%			LAB SUP CHECK:		
			H. B.		
			ENGRG CHECK:		
			I. F. L.		
Cell No.	2146	2203 END OF CHARGE VOLTAGE	CYCLE NUMBER	2376	2476
25	1.48	1.49	1.51	1.51	1.50
26	1.52	1.52	1.52	1.52	1.52
27	1.56	1.56	1.55	1.54	1.56
35	1.55	1.54	1.54	1.53	1.54
38	1.54	1.53	1.53	1.53	1.53
Cell No.	2146	2203 END OF DISCHARGE VOLTAGE	CYCLE NUMBER	2376	2476
25	1.27	1.28	1.30	1.30	1.28
26	1.29	1.28	1.30	1.30	1.28
27	1.24	1.24	1.27	1.28	1.22
35	1.27	1.26	1.29	1.29	1.26
38	1.28	1.29	1.30	1.30	1.28

GENERAL DATA SHEET

TEST Cycle Life at -10°C	SPEC:	PAR:	TEST NO: Report 28
CONDITIONING: Chg: 115% of dischg, 60 min; Discharge: 10% Depth, 40 min			DATE: 20 Aug. 1963
MATERIAL: Ni-Cad: 10 Cell Group. Rated 6 A. H.			TEMP: RH:
MANUFACTURER: Gulton			M. NO: VO-6HS
INSTRUMENTS: Milliammeter, D.C. Sensitive Research, Model UUP, 1/2% Voltmeter, D.C. Weston 931, 5000 ohms/volt, 1/2%			TESTED BY: D. M. LAB SUP CHECK: H. B. ENGRG CHECK: I. F. L.
Cell No.	3276	CYCLE NUMBER	3606
		3333 END OF CHARGE VOLTAGE	
617	1.54	1.54	1.54
619	1.60	1.60	1.60
620	1.54	1.54	1.55
623	1.55	1.55	1.55
627	1.54	1.54	1.54
631	1.60	1.60	1.59
780	1.51	1.51	1.51
783	1.54	1.54	1.54
798	1.54	1.54	1.54
801	1.54	1.54	1.55
END OF DISCHARGE VOLTAGE			
617	1.26	1.26	1.28
619	1.27	1.27	1.29
620	1.25	1.26	1.27
623	1.25	1.25	1.26
627	1.27	1.27	1.28
631	1.27	1.27	1.29
780	1.28	1.28	1.30
783	1.27	1.28	1.29
798	1.27	1.27	1.28
801	1.26	1.27	1.28
14			